#### MOD Based YBCO Films DoE Wire Workshop January 21, 2003

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# AMSC Approach to High Ic YBCO Films

- Metal-Organic-Deposition of YBCO on bi-axially textured templates
  - MOD process is applicable to all template technologies
    - YBCO performance of 200A/cm-width (2.2 MA/cm²) achieved on both RABiTS™ and IBAD substrates (77K, sf)
      - Major focus is RABiTS<sup>TM</sup>
  - MOD process is scalable to long length, continuous processing
    - 10 meter tapes routinely processed on RABiTS<sup>™</sup> templates
    - Critical currents of ~130A/cm-width over length (77K, sf)
  - MOD process is compatible with high rate low-cost (\$10/kA-m) manufacturing



#### The MOD Process for YBCO Films



Metal Organic Precursor deposited on buffered substrate by conventional web coating technology

**Decomposed precursor film** 

Substrate/buffer

Reel-to-reel thermal Decomposition of precursor to a "Y<sub>2</sub>O<sub>3</sub>-BaF<sub>2</sub>-CuO" film

**YBCO film** 

Substrate/buffer

"Y<sub>2</sub>O<sub>3</sub>-BaF<sub>2</sub>-CuO" film converted to YBCO in reel-to-reel system

All processes are are developed for highrate, low-cost manufacturing



## Current Performance of MOD-based YBCO

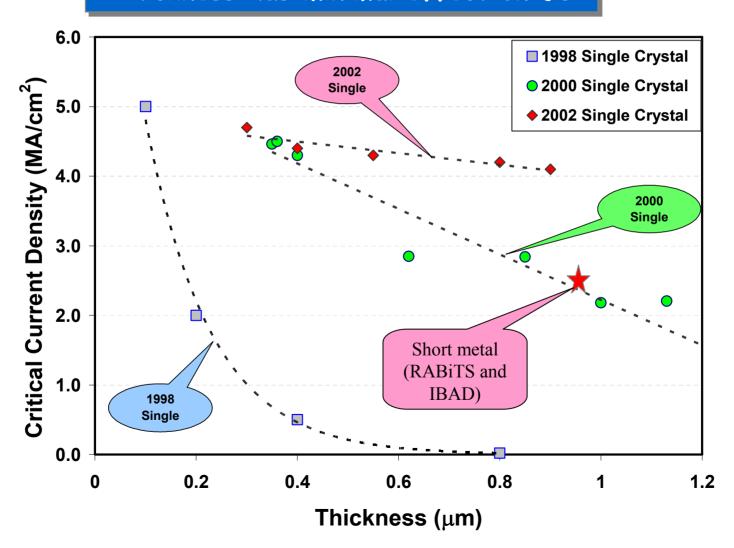
- Performance on CeO<sub>2</sub>/YSZ (single crystal)
  - 4 MA/cm<sup>2</sup> at 0.8 μm YBCO
- Performance on CeO<sub>2</sub>/YSZ/Y<sub>2</sub>O<sub>3</sub>/NiW
  - 2.2 MA/cm<sup>2</sup> (200 A/cm-w) @ 0.9 μm on short samples
  - 1.5 MA/cm<sup>2</sup> (135 A/cm-w) @ 0.8 μm on continuous (1 10 meter) tapes
  - Baseline process for 10 meter lengths

Performance comparable to best PLD films

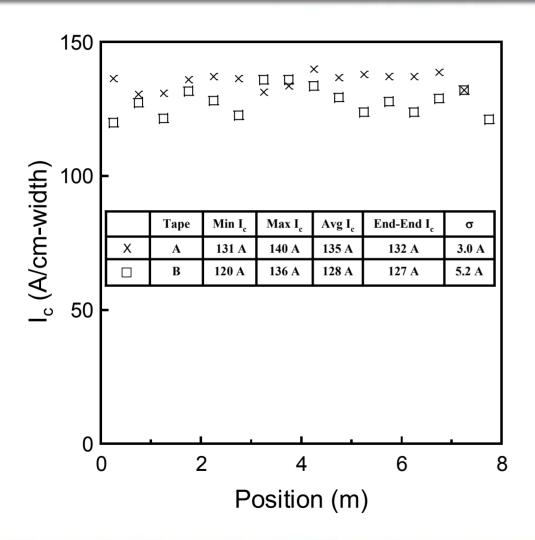


# MOD YBCO Performance Continues to Improve

#### Thickness has minimal effect on Jc



## MOD Process Scales to Length



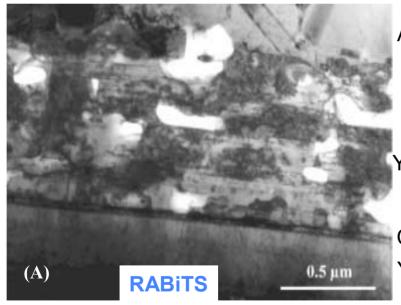
Critical current of the 7.5 and 8.0 m long YBCO superconducting tapes measured at 77 K, self field. Statistical data is from measurements taken at 50 cm intervals

Uniformity over length demonstrates viability of continuous MOD processing



# What Limits Performance of MOD YBCO Films

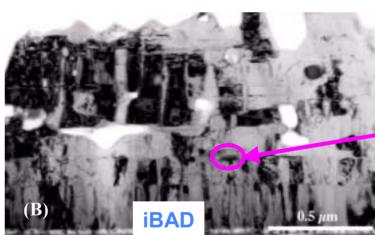
- IBAD samples produce better in-plane texture
  - IBAD: YBCO: Δφ<sub>103</sub>= 2.5°
  - RABiTS: YBCO: Δφ<sub>103</sub>= 4.6°
- Jc in both samples is 2.2 MA/cm<sup>2</sup> (77K, sf)



Ag

YBCO

CeO<sub>2</sub> YSZ



YBCO

BaCeO<sub>3</sub>

CeO<sub>2</sub>

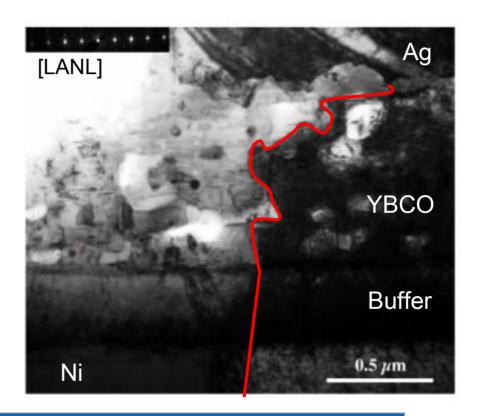
LMO

Jc of MOD YBCO does not reflect difference in texture of templates



# GB Faceting 1 to Surface

- $I_C = 173 \text{ A/cm-w } (77\text{K, sf})$ 
  - 0.9 µm YBCO
- Microstructure of GB
  - Straight GB in substrate and buffer
  - Faceted GB in MOD YBCO



Microstructure of YBCO film important for current path and YBCO properties



# Status of MOD Manufacturing Technology

#### Metal Organic Decomposition Process

- Decomposition time is < 1 hour independent of thickness</li>
- Decomposition is uniform over length and width
  - Original process developed at MIT requires up to 10 hr

#### YBCO Reaction

- Growth rates > 10Å/sec demonstrated with "BaF<sub>2</sub>-type" precursors
- Reaction is uniform over length and width of tape
  - Original process limited to lower growth rates and small samples

MOD process is routinely used for producing 10 meter lengths of high critical current YBCO tape



## Manufacturing Issues - MOD Coating

- Major advantage of MOD-based process is the ability to process wide tapes
  - Coating technology widely used in coating industry and is expected to operate at 2 -10 meters/minute on wide webs
  - Process produces uniform coating over both length and width of tape and is stable over time
  - Materials usage is ~ 100%
  - Precursor cost is negligible
  - Coating run limited by substrate length





# Manufacturing Issues - Precursor Decomposition

- Thermal decomposition of MOD precursor film to a defect-free "Y<sub>2</sub>O<sub>3</sub>-BaF<sub>2</sub>-CuO" film
  - Films are uniform in thickness over length and width of tape
  - Decomposed film is comparable to e-beam "BaF<sub>2</sub>" films
- Entire thermal decomposition is now carried with reel-to-reel process with total time < 1 hour
  - Process produces defect-free films over length and width of substrate
  - Conventional process developed at MIT required times up to 10 hours



A single 10 meter oven produces ~0.25 linear kilometers of web tape each day

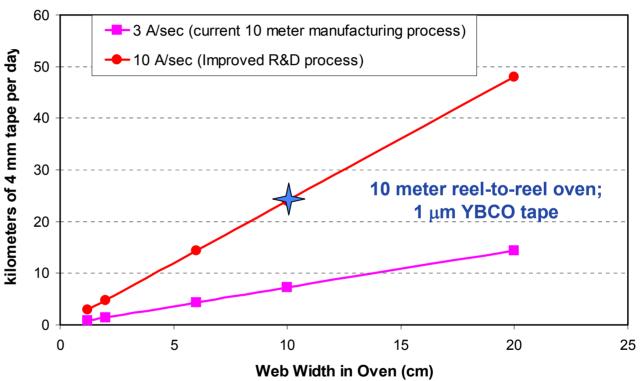
A 10 cm wide tape yields 6.25 km of equivalent 4 mm wire each day



## Manufacturing Issues - YBCO Reaction

Practical, cost effective manufacturing is achieved with MOD process

- Reel-to-reel process
- High growth rates
- Wide web processing capability
- Complete uniformity over web surface
- Maximized Ic over length



MOD Processing Achieves all Requirements

